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APPENDIX

TO THE

DESCRIPTION and USE

OF THE

GLOBES.

CONTAINING,

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| <p>I. ANIMADVERSIONS upon the Structure, Apparatus, &c. of a Set of <i>New Globes</i> lately published; as also on the Book of their Uses.</p> <p>II. A New CONSTRUCTION of ORRERIES, with the great Variety of Phænomena they represent, and the extreme Degree of Exactness at a small Expence.</p> <p>III. Mr. GRAHAM'S New Instrument for finding the LATITUDE at SEA by two Observations on the Altitude of the SUN or STARS.</p> <p>IV. The USE of the GLOBE in finding the true DISTANCE of the MOON from the SUN</p> | <p>or a Star, by the observed Distance.</p> <p>V. The <i>Rationale</i> of correcting the PLACES of the STARS on the <i>Celestial GLOBE</i> when necessary.</p> <p>VI. The Principles of the ancient <i>Canicular ASTRONOMY</i> explained by THEORY and Calculations.</p> <p>VII. AN ABSTRACT of Mr. HORNSEY'S Account of the ensuing TRANSIT of VENUS; with Directions subjoined for making a HELIOSCOPE to view the Phases to the best Advantage.</p> <p>VIII. POSTSCRIPT to the <i>Reviewers</i> Remarks.</p> |
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The Whole illustrated by a large COPPER-PLATE.

By BENJ. MARTIN.

L O N D O N:

Printed for, and Sold by the AUTHOR, in *Fleet-street*,
and by the Booksellers in City and Country.

M DCC LXVI.

P R E F A C E

THE YOUNG MAN, who is the subject of this
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P R E F A C E.

MY writing this APPENDIX was principally occasioned by a late Publication of New Globes, which were pretended to be less defective in their Construction, less difficult in their Use, and contrived to solve the various Phænomena of the Earth and Heavens, in a more easy and natural Manner than any hitherto published.

If this had been really the Case, I knew what Sort of Fate must attend Mr. Senex's Globes, and consequently how far my own Interest would be thereby affected, as it is a principal Part of my Business to make those (hitherto esteemed) most compleat, most elegant, and useful Globes.

*I judged it necessary therefore, to be well informed of the true State of the Case, and accordingly I purchased a Pair of the New Globes 12 Inches in Diameter. I then carefully examined their New Construction, and according to the best Judgment I am able to form of it, I think it so far from being any Improvement of the Globes, that it is quite the Reverse, viz. that it is a more defective Construction, more difficult to use, and much less adapted to explain the Phænomena of the Earth and Heavens than any Globes of the usual Construction. And Prudence, as well as Justice, require that the Particulars of this New Construction should also be laid before the Public, that they may be in some Measure able to judge for themselves; and since, in all such Cases, no Person concerned should insist on his bare Word being taken, I am ready to satisfy any Gentleman of the Truth
of*

ii P R E F A C E.

of all I have advanced, by actual Inspection of the Globes themselves.

These are not my Sentiments of the Globes, only; I have found all that I have shew them to, of the same Opinion; and I can name two Persons of unquestionable Veracity, who will testify that a certain Gentleman of the ROYAL SOCIETY, and whose Name is well known in the Astronomical World, did most solemnly declare in their Hearing, that these New Globes were the WORST OF ANY hitherto made. After this, I need say no more.

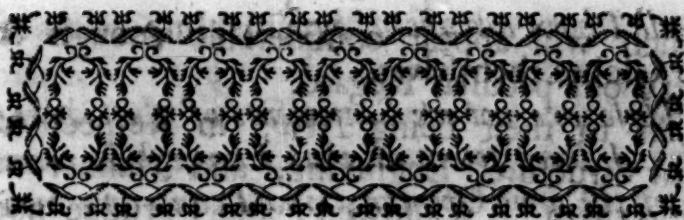
If any think I have treated the Author with less Ceremony than he deserves, they must give me Leave to inform them, that he must be conscious, none at all is due to him from me. If it be said the Stile is ludicrous and low; I answer, it is, and must be so, to be suited to the Subject; for whether you regard the Globes, or the Book—Spectatum admitti, Risum teneatis Amici?

Mr. Senex's Globes have been sold in Preference to the New Globes, to those who have seen both, more than once; and they will never lose the high Estimation they have acquired all over the World by the sensible and judicious Part of Mankind.

I have added many other Sections upon Subjects very interesting and curious, and tend much towards extending the Use of the GLOBES, ORRERIES, &c. as the Reader may be convinced of by perusing them.

Fleet-Street,
Sept. 1, 1766.

B. MARTIN.



SECTION I.

ANIMADVERSIONS *upon the* NEW
CONSTRUCTION *of* NEW GLOBES
lately published, and a TREATISE
of their Use, humbly submitted to
the Consideration of the PUBLIC.

THE Maker of the New Globes,
lately published, has asserted,
that their Construction is new
and peculiar, and that they
are contrived to solve the vari-
ous Phenomena of the Earth and Heavens in
a more easy and natural Manner, than any
hitherto published——The first Part of this
Assertion I readily grant is true, at least, as
to their being peculiar; for that they have
many Peculiarities no Body, who has seen
them, will pretend to dispute; some of
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which will appear considerable enough to merit our peculiar Regard.

As to their being *New*, in Respect of their Structure, Engraving, and Manner of using them, it is allowed; and I grudge not the Author the extraordinary Glee with which he seems to enjoy this Novelty. They may also be said to be *New* in Regard to their Publication; but if we consider the Word *New* as opposed to *Old*, their Novelty in this Respect will admit of a Query. A few Years can make no great Difference for a *Terrestrial Globe*, but the Case is quite otherwise in the *Celestial One*. By a *New Celestial Globe*, the public might naturally expect a Globe just now made, and the Stars all in their *true Places*, answering to their Places in the Heavens for the *present Time*. But here they must be aware of Mistakes; it being many Years since these Globes were first put in Hand; and since in 72 Years the Places of the Stars in *Longitude* and *Right Ascension* vary near *one Degree*, they will be out 30 Minutes in 36 Years; and 15 Minutes in 18 Years; and therefore will stand in need of Correction by Tables, when great Accuracy is required.

Hence Novelty can be no great Recommendation to a *Celestial Globe* in general, and never can give (of itself) a Preference to any particular Globe, by whomsoever made. For when Correction becomes necessary, as
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in a few Years it must, it may be as well made for one Globe as for another. But unless Celestial Globes are of a large Size, even this very Correction will be a vain Thing to propose. I am inclined to think that those who are competent Judges will see but little in this Argument—Few being weak enough to be taken with the *bare Bait of Novelty*.

But these Globes (we are told) are *peculiar*, as well as *New*. Without any Criticism on the Phrase, I freely allow them to be possessed of the following *Peculiarities*, viz.

First, They are *destitute of Hour Circles* about the North Poles; and are the first I have ever seen or heard of, that are so. I believe very few Globe-Makers are to be named, who did not know the Use of the Equator and Meridian, with Respect to the Division and Measure of Time; but not one of them all had the Ingenuity to demonstrate that they could with equal or greater Ease and Utility be substituted in the Room of the *Horary Circle and its Index*; the Students of Globes have therefore hitherto been deprived of the *new and peculiar Privileges* which THEY enjoy who purchase and practice by these *peculiar Globes*.

Secondly, The next Thing *peculiar* to these Globes, is, that they are *fastened within their Frames*, and in such a *peculiar Manner*

also, as renders it to no Purpose for any Person who is not a Mechanic to attempt to take them out: The Wisdom of all preceding Globe-makers has judged it absolutely necessary that Globes should be at Liberty to be taken out of their Frames, to answer many Purposes which Use and Curiosity frequently suggest to the Student — But by this New Invention it particularly appears, that *every Generation grows wiser and wiser.*

Third; The third Pecularity of the *New Globes* is in Consequence of the other two, viz. a *Brass* Semi-circle of round Wire, passing through the *strong Brass Meridian*, in which it is fixed by a Screw, as at each End it is fixed to the Wooden Circle of the Horizon; upon this, on each Side the Meridian, slides an Index or *Minute Pointer*. This Semi-circle not only shackles the Globe, but is productive of another Effect, such as no Man who makes, or uses Globes, would have thought of, or wished for, but the Author of these *New Globes*, who will securely enjoy the Honour of this Invention without Envy, viz.

Fourthly; It is peculiar to these *New Globes* that *neither Pole can be elevated 90 Degrees, or raised from the Horizon to the Zenith*; this we shall shew by-and-by, when we take Notice of the ACCURACY of these *New Globes*,

Fifthly;

Fifthly ; Though the moveable Meridian is not peculiar to the Globes in Question, yet the placing a *moveable Sun upon it on the Celestial*, and a moveable or *sensible Horizon* on the Terrestrial Globe is really a Peculiarity ; and by those whose Understandings are destined to be improved by these New Globes, will be found a very *sensible Invention*, and every Way *worthy of the Author*.

Sixthly ; The *Peculiarity* which we are next pleased withal, is an *artificial Moon sliding upon a Silken String*. If this be one of the *humble Labours by which the Author has endeavoured to improve the Instruments of Science*, for which he has *boldly solicited* the Patronage of his MAJESTY, I will venture to say, that were his MAJESTY's Patience not equal to his Goodness, he could never look upon this as an Object worth his Royal Regard in the Use of the Globe.

Seventhly ; *There are many Arabic Words in Arabic Characters, engraven upon the Celestial Globe*, for the Sake of his *Arabic Students*, undoubtedly ; that no one else can be benefitted by it, is evident, as there is no *Interpretation* on the Globe, nor any in the Book : But there is great Honour in being reputed a *Linguist* ; and who knows but that the Author of these New Globes may be as well skilled in the *Oriental Languages*, as he is in the *Mathematical Sciences*. However this may be, it cannot be denied that *Arabic*
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Characters on English Globes are both a *Novelty* and *Peculiarity*. And 'tis pity the Book wants that *Decoration*, for Want of an *Arabian Type*.

Eighthly; The *Manazil al Kamer*, or 28 *Mansions of the Moon*, being placed all round the *Zodiac*, about and upon the *Ecliptic*, and *Equator*, must not only be esteem'd an Improvement of this Instrument of Science, but the greatest Step towards an universal *Eclaircissement* in the polite Study of the Use of the Globes, and tend greatly to facilitate the *Attainment of Astronomical Knowledge*; and particularly in the *New Method of discovering the Longitude at Sea*. This is, indeed, a New Discovery of the Use of the *Manazil*; and their Insertion a singular *Peculiarity* of this *New Globe*.

Ninthly; The *Addition of fourteen New Constellations*, is (and I believe always will be) a *Peculiarity* in this *New Celestial Globe*. The SIEUR DESNOS has done the same abroad; and I a little wonder at it in him, as I cannot persuade myself to think Mr. SENEX (had he been living) would have done any such Thing. Indeed He added two trifling Ones, viz. *Cor Caroli*, and *Robur Carol*. but this was in Compliment to a KING; and did no Harm to the Globe: But that He would have put on his Celestial Globe 14 Constellations, repleat with the smallest Stars, with the most vulgar and cumbersome Sym-

Symbols, and of Course not only useless in themselves, but prejudicing the Use of others, is not at all probable. Of the *Ten Thousand Stars* observed by De la CAILLE, he himself has made use of but very few in his *Astronomiæ Fundamenta*, that were not known before: These Stars in the Firmament shew the *Handy Work* of their Maker, but on the Globe they shew *just the contrary*, in my humble Opinion.

There are several other Things which the Maker of these New Globes pretends are *new and peculiar*, but some of them are too trifling to be mentioned; while others are asserted to be such with as *little Truth* it seems as he has *Knowledge of the Matter*. For who but a Person most miserably unskilled in the Art and Mystery of *Globe-Making* could ever assert so gross a FALSEHOOD, as *that the Elevation of the South Pole was a Thing IMPRACTICABLE in the Use of common Globes?* I have not only made them, to have each Pole elevated with equal Ease (and in different Ways) ever since I have been in the Trade, but they were made so long before; and I have no Fear of being accused of an *audacious or mendacious Asseveration*, when I aver that the worst Method I have seen used by others, is far more useful and rational than this of *his*, though so *new and peculiar*.

The Author of these New Globes is pleased further to assert——*That they are contrived*

trived to solve the various Phenomena of the Earth and Heavens, in a more easy and natural Manner than any hitherto published. But from what has been observed in the last Paragraph, our Author ought not to think it very indecent in me, if I put a *Query upon the Truth of this Assertion* likewise. As to the EASINESS of their Use, above others, wherein does that consist? Must not these New *so-contrived Globes* be turned about on their Axis? Be *elevated and depressed* in their Frames? Have their *horary Index* set to the Time on the Hour Wire? The *Quadrant of Altitude* fixed to the Meridian? And is not all this to be done by the Person who uses them? Then pray what Labour, what Manual Operation, is there less in these, than in other Globes? If none (for none I have been able to find,) then where is the *greater Ease* in using them.

Then as to the Truth of the second Part, *viz.* shewing the Phenomena *more naturally* than any others, as this is a Matter of still greater Consequence, we ought to have had much better Proof of it, than a bare *Ipse dixit*; Wherein does the *artificial Globe* differ from the *natural one* (the EARTH) but in the Appurtenances of an *Apparatus*? Does not that Globe, therefore appear most natural, that is least incumbered and shackled with these Appurtenances of Circles, Strings, &c. &c. &c.? The Question then is,

is, which is the most simple Construction, that of Mr. *Senex's Globes*, or that of the Globes lately published? They who have not an Opportunity of seeing both, may give a pretty near Guess, by considering that the Price of the latter is 5 Guineas, and of the former only 3, of the 12 Inch Size.

By the Globe formed into a *Tellurian*, the Phænomena of the annual and diurnal Motions are most naturally and simply represented, even by the Consent of our learned Author (for I suppose he means this Instrument by what he calls a *Tellarium*;) and if so, then how is this done but by the Instrument's having a greater Semblance to Nature in a less *Apparatus* of artificial Contrivances?

The Method he has invented to supply the Want of a *Tellarium* (whatever is meant by it) is as high a Thing as any in his Book (Page 53, &c.) and what is greatly becoming the KING's *Aximuth Compass-Maker*, is to inform his MAJESTY, that the *Variation of the NEEDLE at LONDON is between 19 and 20 Degrees*; when his MAJESTY, no doubt, can inform him, in return, that the Variation is between 20 and 21 Degrees.

We have taken Notice of these Globes, in what relates to their being *New* and *Peculiar*, *Easy* and *Natural*; but the greatest Point of all remains as yet untouched, viz.

The TRUTH of these New Globes. I don't find the Author has any where directly asserted, or descanted upon this essential Property of Globes; however as he has thought fit to acquaint his MAJESTY *that he has made these Globes less defective in their Construction*, it is the same Thing as to say, *they give Solutions to Problems with greater Truth*; for the less defective any Machine is, the greater Perfection and Truth we may expect from the Operations depending upon it. It will therefore be worth while to enquire how far these Globes may be allowed to vie with, or exceed those of Mr. SENEX in Respect of Truth and Accuracy.

I. And in the first Place let us cast our Eyes upon the *strong Brass Meridian*, and we shall find that it is almost HALF an INCH more in Diameter than the Globe itself, (in the 12 Inch size) whereas Mr. SENEX's Globes have their Meridians little more than $\frac{1}{2}$ the Tenth of an Inch from the Surface; and consequently as the *General Meridian* is to represent those that are really fixed *upon the Surface*, those on Mr. Senex's Globes are about four times nearer to the Surface, and therefore so much *nearer to the Truth*, than the other.

II. The same Deficiency from Truth in these New Globes, and the same Proximity to it in those of Mr. Senex, appears also in the Hori-

HORIZON, or *broad Paper Circle* in our Author's *New Stile*.

III. Both the North and South Parts of the Horizon, which should have been (as in other Globes they are) contiguous to the graduated Side of the Meridian, are cut away in these New Globes to the Distance of full $\frac{1}{2}$ of an Inch : So that with Regard to all Problems relative to the LATITUDE of Places, DECLINATION of Stars, ELEVATION of the Poles, BEARING of Places, AMPLITUDES, AZIMUTHS, &c. of Stars, I say, in all these grand Problems at what an enormous Distance are we from the Truth ! And therefore when these Globes are asserted to be of a *less defective Construction* than others, we are quite at a loss to conceive what Opinion our Author could entertain of the Judgment or Sense of those who were to use them.

IV. But if any Advocate can be found for any Thing so bad as the above Construction, he will put us in Mind of an Advertisement at the End of the Preface, wherein you are directed to remedy all these Inconveniences by cutting of a Card *secundum Artem*, and by applying it, *apropos*, to the Surface of the Globe, Meridian, Horizon, &c. &c. &c. But will every Purchaser of these Globes conceive he has Dexterity enough for executing such a nice Affair ? Or if he has, will he not think it hard, that after having pur-

chased Globes at an excessive Price, he should still be left to put his Ingenuity to the Rack to construct Materials and Implements for using them, himself? But supposing still further, that he has as much Patience as Money, yet how is he to posite the Card upon the *broad Paper Circle*, so that its Edge may be applied to the *strong Brass Meridian* in such Manner as that the Degree, and Parts of a Degree, may be ascertained with *such sufficient Accuracy* that the North Pole may thereby be *elevated EXACTLY*.

V. But let us hear what the Author of these *less defective* and *less difficult* Globes is pleased (or forced, shall I say?) to declare of them himself, these are his Words——

“ It is frequently required to know what POINT upon the *strong Brass Meridian* or *broad Paper Circle*, exactly answers to a given POINT upon the Globe, and (says he) this CANNOT BE WELL KNOWN BY INSPECTION, ON ACCOUNT OF THE NECESSARY DISTANCE OF THESE TWO CIRCLES FROM THE SURFACE, &c. Here then is an *ingenuous* and *honest Confession of the plain Truth*. Such CANDOUR is rare to be found in an Age abounding with so much *Cunning*, and especially in TRADESMEN characterising their *Own New and peculiar PERFORMANCES*.

VI. The next Proof of these Globes being *less defective* than others, is, to be sure, that the Equator and equinoctial Line is *entirely eclipsed* from our *direct View* by the *Opake Body*

Body of a Brass Wire placed directly over it. Sir FRANCIS ——— who lately made a Purchase of a Pair of these Globes, declares he is obliged to bend his Head as obliquely as a PARROT does, to get a View of this important Circle, and its minute Divisions, when he is to find the *Hour* and *Minute*, *Right Ascension*, *Oblique Ascension*, *Culmination*, &c. of any of the heavenly Bodies, which are all to be sought for in that Circle. And Captain SURGE is constantly execrating this Brass Circle over the EQUATOR, which he believes will prevent (at least make it *very difficult*,) for him to find the LONGITUDE by SEA or LAND either.

VII. Another Proof of these Globes being *less defective than others*, the *same Brass Wire* will very readily furnish; (of what prodigious Service is this Pittance of Wire upon these New Globes!) For being itself *one Tenth of an Inch Thick*, and carrying an Index, which is *twice that Thickness*, it must cause, that in the best Position of the Index, the equinoctial Line (or the Equator) cannot come within $\frac{1}{10}$ of an Inch of the Horizon in the South or North Parts, which is a *whole Degree*; and if the Hour Index be placed near *Aries* or *Libra*, the said Lines will want several Degrees of Coincidence with the Horizon, and by just so much, or so many Degrees will it be impossible to bring the Poles into the Zenith, or elevate them to 90 Degrees.

VIII. Hence

VIII. Hence it follows *that only two of the three different Positions of the Sphere* can be truly represented on these Globes; that of the parallel Sphere being *impossible*, where the Pole cannot be placed in the Zenith. And may we not deem this a most flagrant Proof of the *less defective Construction* of these New Globes?

IX. It will be found by measuring the QUADRANT of ALTITUDE, that it is a Quarter of a great Circle upon the Globe, and is accordingly divided as such, but when one End of this Quadrant is elevated and affixed to the Meridian at so great a Height above the Globe, and the other End strongly springing against the Horizon at such Distance from the Globe, will this *New Globe-Maker* say, that this is in such Circumstances a *Quadrant of Altitude*, i. e. The proper Measure of the ALTITUDES of the Sun or Stars above the Horizon, or of their AZIMUTHS from the Meridians? Every TYRO in *Spherics* knows it becomes only a *Segment of Circle* of a large Sphere, improperly divided into 90 Degrees; and can only touch the Globe, for which it is made in the Middle Part, instead of lying closely upon its Surface throughout. Lo, here, is another Instance of a *less defective Construction* of Globes!

X. But what will give the most exalted Idea of a Genius for Improvements is, that in Problem XV, (Page 68.) To find the
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Sun's Altitude, he has directed the artificial Sun to be placed over the Sun's Place in the Ecliptic, and then by moving the graduated Edge of the Quadrant to the Center of the artificial Sun, he tells us, *the Degree of the Quadrant which is cut by the (artificial) Sun's Center, is the Sun's Height at that Time.* But in that Set of 12 Inch Globes of this New Construction which I bought, when I was following these sage Directions, and had at last fumbled out a Solution of the Problem on this New Celestial Globe, and also on that of Mr. *Senex's* for the same Moment of Time, I found the Height of the natural Sun upon the latter to be *more than two Degrees* less than that of the *artificial Sun* upon the former. Now 'tis evident that one of these Globes must be *shamefully defective in Construction* indeed; but which, is left to the Reader, partial, or impartial, to judge.

XI. From hence may be gathered the Reason, in general, why so very few of the Problems in this extraordinary Book are illustrated by *EXAMPLES*; for had this 15th Problem been thus illumined, we had seen (too clearly perhaps) the *Defect of Construction* in Comparison of others; and this would have been a woeful Affair after he had given his *MAJESTY* an Assurance of the Contrary. In fine, those who have to do with *artificial Suns and Moons*, ought to be content with *artificial Altitudes, Azimuths, &c.* But such
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as aspire to nothing more than what is purely simple and natural, may find it all in Mr. *Senex's* Globes.

XII. The Method of engraving the *Calendar* and *Degrees of the Sun's Declination* (usually called the *ANALEMMA*) upon the Meridian about the North Pole is nothing New or peculiar, it being the Invention of the late Mr. *Joseph Harris*, about 30 Years ago, which was probably before these Globes were began. But Mr. *Harris* observes at the same Time (N°. 456 of the *Transf.*) that *GLOBE-MAKERS might save the TROUBLE and EXPENCE* of engraving this upon *Brass*, by doing the same Thing upon the Paper of the Globes; this Advice Mr. *SENEX* took; but they who pay 5 Guineas for Globes instead of 3, ought to have some valuable Consideration for it, viz. a *BRASS ANALEMMA*, instead of a *Paltroon paper one*, that will cost little or nothing.

XIII. The *Crepuscular Circle* is another Article, neither *New nor peculiar*; and I think moreover, if it does not prove the Construction of the Globe *defective*, it proves itself very defective; being only Scantlings of *common Brass Wire* of *Three Half Pence per Oz.* Those made by Mr. *Senex* were doubtless of a different Construction; and the Globes made since his Plates came into my Hands, have never been *disgraced* with rough and unwrought

wrought Materials, and so inartificially placed as to be of little or no Use.

XIV. In regard to the COMPASS, as it is, and always has been an Appendage to Globes, I have only this to observe, that Mr. *Senex's* Method of applying this useful Part, is greatly preferable to that we find in these *New Globes*; is much less expensive, and fixed with greater Certainty and Truth.

XV. All the Articles hitherto mentioned are relative to *Deficiency*; let us next see what may be found *redundant* in these *New Globes*; and the first Thing observable of this Kind is not only *New* but *very peculiar* indeed; we are told by this Author (Page 43.) That there are FOUR COLURES. I must confess this is the first Time I ever heard of that Number; Mr. *Senex* never had more than *two* upon his Globes: Nor can I find above THREE out of the FOUR upon these New Globes, viz. *one Solstitial Colure*, and *two Equinoctial Colures*; it is true, indeed, he speaks of *Solstitial Colures* in the plural (Page 44) and says they are made out of *two Meridians* passing through the Points marked S and v; upon other Globes there is but *one Meridian* which can possibly pass through these two Points. If we allow of this new Invention for making Colures, we shall find at least *five* upon these New Globes, viz. *two Solstitial*, and *three Equinoctial Colures*. For besides the equinoctial Colure passing

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through

through γ , and the other Equinoctial Colure passing through \simeq , there is it seems, a *third Equinoctial Colure* passing through the 24 Degrees of the Equator, East of the Point \simeq . It is true, he does not (*totidem Verbis*) say it is the *Equinoctial Colure*, but only *the Colure, or Equinoctial Meridian, A. D. 1753, @ \simeq*. And this *fifth Colure* is distant from γ , or the first Meridian passing through *Greenwich Observatory*, 156 Degrees to the West; for the wonderful Invention of which, and the extraordinary Use made of it, see Page 126, &c. of the Book, by which the Reader will be convinced that the said Book is every Whitt as *new and peculiar* as the Globes it describes; it being the *first Time* undoubtedly that ever an *equinoctial Meridian* was heard of *that did not pass thro' the Equinoctial Points*.

XVI. In other Globes it has been always adjudged sufficient to number the *Degrees of Longitude* each Way to 180 Degrees from the first Meridian; and all the modern Books, Maps, Tables, &c. are formed according to that Method of reckoning; but the Purchasers of *Our New Globes* are not to be fobb'd off with Things done thus *to halves*. He not only gives them the *two Halves*, but the Whole Circle into the Bargain, and roundly reckons on from 0, to 360 Degrees without stopping. The Equator thus surrounded by two *Phalanges* of Figures above, and one of
a double

a double Notation below, appears numerically equipped beyond any Equator upon a Globe, since *Eudoxus's* Time.

XVII. I have already taken Notice of the great Addition made to the Number of the *fixed Stars* upon this New Celestial Globe, which we are told are several Thousands more than have appeared upon other Globes. And as it must be allowed there is at least a Thousand more upon other Globes than can be of Use to Mankind in any Shape or Sense whatever, to what Purpose is all this *To-do* about Stars? Are they intended to *illumine* the Globe? If so, why have they such a *caliginous Aspect* on this New Globe! In the Heavens they appear bright and glorious; but I appeal to any One who views the Southern Hemisphere of this Globe, if it does not look more like *Blotting Paper*, than the *Firmament* of glowing Stars.?

XVIII. Under the last Head of Redundancies I may justly reckon the amazing Multiplicity of Names of Places upon the *Terrestrial Globe*, and the most Part of them of little or no Importance; but if the Peruser of such a Globe has no Objection to its being thus crouded, in a small Character, I have none, he may suppose. And if the Author had authenticated his Innovations upon the *Terrestrial Globe* with any more than his *Ipse dixit*, it might have prejudiced the Sale of Mr. *Senex's*; but as the Case stands,

I believe they are pretty safe, and so will remain 'till other Lights are thrown upon *Geography* than what can be expected from this Quarter.

I have done with the Globes; and shall conclude with a few Remarks on the Book that describes them. As to the *Grammatical Part* of it, I will say it is much exceeding what I expected from an Advertisement of it *three times repeated* in the public Papers. I wonder none of his *worthy Friends* could be found to give him a Jog before. In *Orthography* he is not quite so correct as one might expect; for sure the hackney'd Word *Phænomena* is become too common to admit of the Excuse, *Græcum est, non potest legi*. However our Author is resolved to be right by *Hook* or by *Crook*, and therefore spells it every Way it can be spelt, viz. *Phoenomena*, *Phænomena*, and *Phenomena*. As to the Word *Tellarium*, I protest I can find it in no Dictionary, nor can I derive it from any One, or all the Languages together, I ever heard of. His *Eskmios* for *Eskmaux*, *Kanton* for *Canton*, *Antego* for *Antigua*, and a hundred others, will astonish no Body that has read this *peculiar Book*.

In the Title-Page we are told One great Design of the Book is to shew the CORRESPONDENCY of the TWO SPHERES. And though this new Doctrine employs near half the Book, yet after looking it over, I was
just

just as wise as before; for after all the learned and tedious Labour he bestows upon us about the *natural Agreement between Celestial and Terrestrial Spheres, Solar Correspondents, Celestial Correspondents, Correspondency of the fixed Stars, Signal or Warning Stars*, and many *Tables of Correspondency of Stars and Places*, employing near 40 Pages of the Book, I was so stupid as to see no more Correspondency between one and the other Sphere, than appeared before the Publication of these *New Globes*. Nay his Descant upon *Signal or Warning Stars*, and their *Perpendicularity over Peoples' Heads*, must be incomprehensible to those who have studied it no more than myself.

As to the Phænomena of the HARVEST-MOON, we find nothing *New* in the Book; and the *New Globes* will explain them in no *peculiar* Manner, not even so *easy* and *natural* as may be shewn upon the common Sort of Globes, if we are obliged to use his *artificial Sun, Moon, Wires, Strings, &c.* which are furnished for such Kind of Problems.

For a Specimen of *Astronomical Skill*, that is certainly both *new* and *peculiar*, I must refer the Reader to the Book, where from Page 126 to 148, he will find the Method of computing the Time of the *Autumnal Equinox*, and the *Difference of Time* between that and the *Vernal Equinox*, with *Precepts, Tables,*

Tables, &c. of Retrocession, Autumnal Equinoxes, &c. with Calculations for Alexandria, Greenwich, &c. with a Circle for the literal Character of Days, &c. But because these Things do not concern the Globes, therefore the Reader must be left to find out the Meaning himself, and make the best Use of it he can.

The *Methods* of finding a *Meridian Line*, the *Equation of Time*, and *shewing how the Terrestrial Globe will represent the real Phenomena relating to the Earth when actually compared with the refulgent Rays emitted from the great Sphere of Day*, are as incomprehensibly fine, as the Language in which they are presented to us; but here we must follow our Author's Example, and suppose, *the many Advantages arising from these Capital Problems relating to the placing the Globe in the Sun's Rays, an intelligent Reader will easily discern*, and readily extend to his own as well as the Benefit of his PUPIL. N. B. *By an intelligent Reader you are to understand a Teacher of the Use of the Globes.*

I can't conclude without taking Notice of one very extraordinary *Paragraph* in the Preface, though it is *purely Astronomical*, and in which the Globes are no ways concerned; it runs thus;

“ The Table of the Passage of the first Point of Aries over the Meridian, is taken from an EPHEMERIS of (De) LA CAILLE, with

with some LITTLE ALTERATIONS; and has been carefully compared with twenty Years CALCULATIONS made by the same Author. The Necessity, says he, I found myself under of hastening the PUBLICATION of THIS TREATISE, and the various Interruption and Avocations from which a Person in MY STATION cannot be exempt, would not allow ME sufficient Leisure to CACULATE an ORIGINAL TABLE." Here the Public has a right to propose the following Queries, viz. (1.) Why any one has presumed to make any Alterations in Tables of any Sort calculated by the late DE LA CAILLE, without giving a Reason for his so doing? (2.) How have these Tables been carefully compared with 20 Years CALCULATIONS? (3.) How does it appear that the most able Astronomer which this Age has produced, both for *Calculations* and *Observations*, has offered Us a defective Table of the *Passage of the first Point of Aries over the Meridian*? (4.) and in what *Ephemeris* of DE LA CAILLE is there any such Table to be found? (5.) In his *Ephemerides* of the Celestial Motions for ten Years, viz. from 1765 to 1775 there is a Table of the Distance of the first Point of *Aries* from the Meridian of *Paris*, and is variable thro' every Year. Can this be the Table in Question? (6.) Whatever Table is here referred to, and whatever be its Deficiency, if it was of DE LA CAILLE's compiling,

ling, have we any Reason to expect it to be better done *de novo* by our Author from any Specimens we have of his *astronomical Abilities* contained in this wonderful Work?—

From the little I know, or can judge of astronomical Matters, I could not have supposed there was a Man living who would have presumed himself able to mend any such Table of the ABBE *De la CAILLE*.

Our Author has great Hopes that *the Superior Accuracy with which the Plates are drawn and engraved* will appear at first Sight to competent Judges; but if the Public were certified of the Truth of what I have heard from the Workmen, *viz.* that the Plates were done over and over again, in Whole or in Part, and many Changes and Sets of Hands successively employed for many Years past; and that at last it would have been impossible to have got them compleated, had they not hit upon the Expedient of *copying Mr. Senex's Papers of the 17 Inch Celestial Globe*. I say if they believe these common Reports, there will be very few competent Judges found to have any extraordinary Opinion of the superior Accuracy of *copyed Plates*, or to discern it at *first or second Sight* either.

As to the *Drawing and Engraving* of the Plates of the Celestial and Terrestrial Globe in the Book, they are equally *incomparable and peculiar*, and quite beyond the Reach of
Cri-

Criticism. And since they are said to represent these Globes AS *they are improved and constructed by the Author*, it will save us the Trouble of saying any more about the Globes, Plates, or their Engraving.

I shall dismiss this Subject with only one Reflection on our Author's Talent at *moralizing* upon the Works of Nature; for speaking of the PLANETS he observes very gravely, and with great Peculiarity,——*That the Regularity of their Motions, STRICTLY CONFORMABLE at all Times to the LAWS of THEIR CREATOR, exhibits a STRIKING PATTERN of OBEDIENCE to every RATIONAL Spectator.* But why are we sent to the *Planets* to learn this Piece of Rational Deportment, since every Man's CLOCK affords him the same *striking Patern of Obedience.* But if our Author thinks *Rational Beings* will admire his *mechanical Methods* of becoming devout and religious, it is no Wonder if he imagines that his Globes will open a large *Field of Geographical and Astronomical Knowledge*, fraught with *Instruction and Amusement*; since these Things naturally flow from *mechanical Constructions and Contrivances*; whereas the Principles of Virtue and Religion, in order to their being rational, were never before known to be founded in Laws of Nature designed only for *inanimate Beings*, and, of Course, are purely *Mechanical.*

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In short the Reader of this Book ought to have a *new and peculiar Understanding*; how else will he comprehend how a *Circle may represent a Plane* (Page 9)? Or how to supply the Want of a *Tellarium* (Page 53)? Or how the Equator can (in these Globes) ever be in the Plane of the *broad Paper Circle* (Page 60)? Or what is the *nearest Mean Length* of a Tropical Year (Page 127)? Or what is the Use of the *Manazil al Kamer* (Page 205)? Or what is the *Shade of Extuberancy* (Page 224)? Or what are the *Four Cardinal Points* of the DAY? Or what the Use of the Tables at the End of the Book? To pass by many other Things equally incomprehensible by vulgar Capacities.

The Undertaker of a *Task so complicated and laborious* (as writing a *Treatise on the Use of the Globes*) hopes the Reader will make some favourable allowance for him, and correct the Errors for himself, if there *should appear to be any*. This is but a reasonable Request, and it would be cruel to deny it; *Sins of Ignorance* (when we are not needlessly guilty of them) are always *venial*; since *humanum est errare*. But why, since the Task is in itself so grievously hard, should the *Undertaker*, take so much more Pains than was necessary? Who besides this *Undertaker* would *undertake* to use the *Periphraseis*, OUR NEW GLOBES 25 times over, when so many single Words in other Writers suffice?

suffice? Or the Circumlocution STRONG BRASS MERIDIAN, no less than 100 Times? And the irksome descriptive *Tautology*, BROAD PAPER CIRCLE (for the *Horizon*) 75 times repeated? Indeed when we take a proper View of this Work we cannot but exclaim with the Poet, *Hic Labor, hoc Opus!*

I don't apprehend there is any more *Complement* than *Truth*, in the Assertion, *That it is the Privilege of real Greatness not to be afraid of Diminution by condescending to the NOTICE of LITTLE THINGS*——Whatever our Author may presume on that Supposition, I believe most of his MAJESTY's literary Subjects have a better Opinion of his MAJESTY's Judgment than to suppose he can look upon any Thing here called *humble Labours* in any other Light than that in which the Author himself has truly placed them, *viz.* Of LITTLE THINGS, indeed! And whether his MAJESTY's literary Greatness may be liable to no Diminution by condescending to the Notice of them, must be left to the Determination of his most judicious and impartial Subjects.

Thus we have considered most of the *Phœnomena* of a Book dedicated at first to a KING, and may at last perhaps, have the Honour of being devoted to a GODDESS, notwithstanding *all the Correspondency of all the Spheres* it talks so highly of.

At the End of the Book we find a CATALOGUE OF INSTRUMENTS, prefaced in a STRAIN OF RHETORIC that is also *New and Peculiar*. But what I shall take Notice of are the following Expressions, viz. *such Instruments as are either invented or improved by himself, and constructed according to the MOST PERFECT THEORY*. Now I believe I may safely appeal to the Public, and ask if they do not remember *those very Words* in my Advertisements in the public Papers for many Years past? However, any Gentleman may see them in my *Shop-Bills* at any Time. Now he either stole them from me, or I stole them from him; but this Matter will not long be a Subject of Dispute, for unless he can produce Bills or Catalogues which have those Expressions prior to mine, I shall charge him with the *Theft*: He tells us, *he would not willingly incur the Imputation either of PLAGIARISM or INGRATITUDE*; but unless he can acquit himself of the above Charge, he must appear guilty of *Plagiarism*; and also of *Ingratitude* of Course, because he took it without *thanking ME* for it. But how much baser must that Disposition still be, which can permit a Man to take any Thing from another, to which he knows he has not only no Right, but is conscious his Behaviour for *Ten Years* past has rendered him an Object of just Contempt to the Person he steals from? There
are

are other Articles of Impeachment, such as *Achromatic Refractor*, *Manual Orreries*, *Planetariums*, and I suppose his *Tellarium*, are all taken from my Bills, &c.

But when he reprints his Catalogue I must beg the Favour of him not to disgrace my Instruments with such *false Spelling*, but write it *Tellurian*, as I have done. Also some common Words would better become his Catalogue, if they were more properly and intelligibly spelt, as *Pantographer*, *Zografoscope*, &c. This last Word *Zografoscope* is entirely *new* to me, and I believe *peculiar* to this Author alone; the same may be said of the Word *Logarithm* in some other Writings of his MAJESTY'S Mathematical Instrument-Maker.

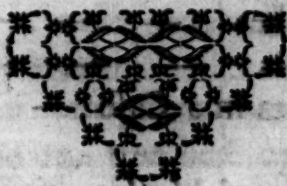
As we are told, that his Instruments are constructed according to the MOST PERFECT THEORY, it would have been but becoming in him to have first convinced the Public that he knows *when they are so*, and *when they are not*; for we are not to take a *Man's Word* only for a Proof of his being a *Mathematician*; besides the Assertion is not true in his Mouth, for he never constructed some Instruments according to *the most perfect Theory*; for Instance, this requires a different Construction and Application of the *Line of Latitudes*, than what you find upon any Scales of his Make, unless he has stolen that likewise from my
Dial-

Dialling-Sector. And were he to sell no more Instruments than what he could demonstrate the THEORY of from genuine PRINCIPLES of GEOMETRY, I believe it would not be the worse for the Rest of the Trade.

He has a New and Curious *Hydrometer* in Hand, it seems; and it very luckily happens, that he could not have pitched upon such another Instrument for giving him an Opportunity to exert his *utmost Faculties*, and whose *Theory displays so ample a Field*. The Truth of which I have found by *seven Years Experience*; the *Physical and Mathematical Principles* of the Construction of my *Hydrometer*, I have long since published; And 'tis hoped my Antagonist will not fail to do the same by his; The Merits of each will then be easily decided by competent Judges among the Honourable COMMISSIONERS of his MAJESTY'S Customs, &c.

I should have taken in very good Part all his Plagiarism and subreptitious Methods of Dealing by me, if he had not been so ungenerous as to *call me Names* for it when he had done. He would have been welcome to all the *Eclat* my *New AIR-PUMPS* have added to his Shop-Windows for many Years past, had he been genteel enough to have told his Customers who they were indebted to for them. No Instrument invented by him, ever appeared in my Windows; Not but that

that if he should at any Time oblige the Public with any Thing that is really better than what they have already, I sincerely declare I shall be the first to acknowledge its Merit; and would scorn to depreciate any Work of public Utility, from what Hand forever it comes; for with me, *Fas est et ab Hoste doceri.*






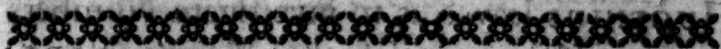
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SECTION II.

A NEW CONSTRUCTION of ORRERIES,
shewing the Great VARIETY of
Phænomena they represent, and
the extreme Degree of EXACTNESS
they admit of at a small EXPENCE.

NO English Author besides Dr. DER-
 HAM in his *Artificial Clock-Maker*,
 has treated upon the Subject of
 ORRERIES, the Mechanism thereof,
 and the Truth of such Work. And what he
 has delivered is quite upon the *Old Plan*,
 and chiefly historical.

Nor has any foreign Author besides the
 Great HUGENIUS, touched upon Calcula-
 tions of this Kind, that I know of. This
 noble Author, in his Tract called the *Auto-*
maton, has delivered the Principles of Calcu-
 lating Numbers for the Planetary Motions,
 and by which he has constructed his *Auto-*
maton or *Planetarium* to such a Degree of
 Truth in the *Mean Motions*, *Excentricities*,
 &c. as far exceeds any Thing of the like Sort
 done by any other Hand.

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But no human Productions are perfect; HUGENIUS leaves us to investigate Numbers for the Movement of the Moon's NODE, and APOGEE, the Mean Motions of the *Satellites* of JUPITER and SATURN, and the Phases of Saturn's RING. But, what is the greatest Deficiency of all, there is not a Word of the Mechanism of the Earth's *Diurnal Motion* about its Axis.

It is this last Article, indeed, that distinguishes an ORRERY from a *Planetarium*, which has nothing more than the *Annual Motions*. As HUGENIUS made use of *Riccio-lus's* Tables, his Numbers and Constructions are not to be expected so correct as those deduced from *modern Tables*, viz. those of HALLEY, De la CAILLE, MAYER, and CLAIRAUT.

From these most correct Tables I have been at no small Pains of deducing a System of Numbers, which will shew the *Annual Mean Motions* of the PLANETS; the *Parallelism* of the EARTH's Axis; the *Diurnal Motion* of the EARTH; the *Menstrual Motion* of the EARTH and MOON; the Motion of the MOON's NODE, and APOGEE; the Motion of *Jupiter's* SATELLITES; the Motion of SATURN'S SATELLITES; with the *Parallelism* of his Axis for the PHASES of his RING. All of which are therefore in as great Perfection as the *present improved State of Astronomy* will admit of.

But

But that the Reader may be in some Degree apprized of the exceeding Accuracy of these Numbers, or how near to the Truth they approach, I shall lay before him the following Sketch for his Satisfaction.

The Planet MERCURY makes 847 Revolutions in 204 Years in this ORRERY; but in the *Heavens*, it revolves 847 times in 204,008 Years; this gives an Error of 16' 56" 16" in 20 Years; which is not one Minute *per Annum*.

The Planet VENUS in the ORRERY makes 395 Revolutions in 243 Years; but in the *Heavens* she revolves the same Number of times in 394,9965 Years; which gives an Error of 6' 28" 40" in 20 Years, or about 20" *per Annum*.

The EARTH's Period about the Sun is here stated at 365^d 5^h 49' 25".

The Planet MARS revolves in the ORRERY 67 Times in 126 Years; but in the *Heavens* the same Number of Revolutions is compleated in 66,9977 Years; hence the Error in 20 Years is not more than 7' 53" 24"; which is about 24" *per Annum*.

The Planet JUPITER makes 14 Revolutions in the ORRERY in 166 Years, in the *Heavens* it performs 14,0018, Revolutions in the same Time; the Difference gives 4' 40" 48" for the Error in 20 Years, not quite 12" *per Annum*.

The Planet SATURN revolves about the Sun in the ORRERY 7 times in 206 Years; but in the Heavens it makes but 6,99895 Revolutions in the same Time. Whence *Saturn* is too fast by $1' 37'' 12'''$ in 20 Years, or $4'' \frac{1}{2}$ *per Annum*.

For the LUNARIUM.

As the Time of Mean Synodical Revolutions of the MOON is $29^d 12^h 44' 2'' 53'''$, there will be 21038 such Lunations in 1701 Years, compleatly; in the Orrery there are 1781 Lunations in 144 Years, which is so very near the Truth, as to differ from it only $28' 30''$ in 20 Years, or but a little more than one Minute *per Annum*.

The *Mean Annual Motion* of the NODE of the Moon's Orbit being $19^\circ 19' 43''$, there will be 67 Revolutions of the Node in 1247 Years; and thence the Mechanism of the Motion of the Node in the Orrery will be extremely near the Truth.

The *Annual Mean Motion* of the MOON'S APOGEE being $40^\circ 39' 50''$, there will be 13 Revolutions in 115 Years; whence also this Motion is represented with great Accuracy in the Orrery.

There may also be added to this Orrery, a second LUNARIUM, for shewing the true *Phases* of the MOON and her *Librations* both in *Longitude* and *Latitude*; which Part has
not

not yet appeared in any *Orreries* that I have seen or heard of.

The *Parallelism* of the Plane of the *Ecliptic* in this *Lunarium* is adjusted to the precise Truth, and the Days of the Moon's Age, and her Latitude in every Part of her Orbit for any given Time, are distinctly shewn.

The TELLURIAN.

In this Part our Numbers are so very exact, that the Axis of the Earth is not only always perfectly parallel to itself, but the *Diurnal Motion* of the EARTH about its Axis is here adjusted to the *Mean Motion of the Sun* to so nice a Degree, that they both begin and end the Year together within less than 30 *Minutes per Annum*. See further concerning the Uses of this curious Part in the foregoing Treatise of the Globes, Page 168, &c. and in the Young GENTLEMAN'S and LADY'S PHILOSOPHY in the GENERAL MAGAZINE for the Year 1760.

The Jovian SYSTEM.

In order to exhibit the Mean Motions of the four *SATELLITES* of JUPITER, we have only to compare their several *Revolutions* with that of the *Primum Mobile*, and from thence we obtain the Numbers for the Construction of this *Jovian SYSTEM*, with all the Accuracy the present State of Astronomy

mony will afford. These periodical Times and Numbers are contained in the following Table.

Satell.	Periodical Times.				Revol.	Days.
	D	H	'	"		
I.	1	18	27	35	19	34
II.	3	13	13	42	20	71
III.	7	3	42	33	110	787
IV.	16	16	32	8	16	267

The Saturnian SYSTEM.

In the same Manner you observe the Periodical Times, and *Ratios* of the Numbers which compose the Mechanism of the *Saturnian* SYSTEM, in the Table below.

Satell.	Periodical Times.				Revol.	Days.
	D	H	'	"		
I.	1	21	18	27	98	185
II.	2	17	41	22	19	52
III.	4	12	25	12	29	131
IV.	15	22	41	12	55	877
V.	79	7	47	0	34	2697


The PHASES of *Saturn's Ring* are provided for by the proper Inclination and Parallelism of its Axis. So that at any Time of his Period they are the same in the *Orery*, as in the Heavens; and thus all the *Phænomena* of the *Annual*, *Mensrual*, and *Diurnal*

Diurnal Motions of the Planets, Primary and Secondary, are exhibited in this Construction of an Orrery with much less Expence, and far greater Accuracy, than could be attainable with Numbers less perfect than those we now have; not only so, but I have never seen, or heard of any Orrery, that will exhibit all the above-mentioned Appearances with any Numbers, or by any Construction at all, not even those which have been sold for 1000 Guineas.



SECTION. III.

*Mr. GRAHAM'S New INSTRUMENT
and METHOD of finding the LA-
TITUDE at SEA, by two Observa-
tions of the Altitude of the SUN
or STARS.*

 HIS Problem so very difficult in Theory and Calculation, and yet so extremely necessary to the Perfection of Navigation, will admit of a very easy and exact Solution by the GLOBE, or an Instrument made of Part of a Globe, which was some Years ago described in

in the *Philosophical Transactions*, Vol. VIII. Page 371, by the Inventor Mr. R. GRAHAM; this Account of so useful an Instrument and Method of finding the Latitude we shall here transcribe, as it immediately depends upon the Nature and Use of the Globe, which, if it be of the largest Size, or that of 28 Inches in Diameter, will give a Solution to the Exactness of a Minute with great Ease. His Account is as follows, in his own Words.

The Necessity of finding the Latitude a Ship is in, is too well known to be insisted on: Frequent Opportunities of observing the Latitude must consequently be of very great Advantage to Navigation. The Method usually practised, is by taking the Sun or Star's Meridian Altitude or Zenith Distance: In this Case, if the Sun does not shine but for some small Time only, before Noon and after, though it be clear all the rest of the Day, it is of no use for this Purpose. Mr. *Fatio*, F. R. S. (in the Year 1728) proposed a Method for finding the Latitude, from two or more Observations of the Sun (or Stars) at any Time, the Distance of the said Observations in Time, being given by a Watch; but as his Method requires a vast Number of Computations, and a great deal of Skill in Spherical Trigonometry, it has very seldom been made use of, and never but by good Mathematicians. The Instrument here de-
scribed

scribed will answer the same End, and has these Advantages, *viz.*

1st. It may be very easily understood by Sea-men.

2dly. It immediately shews the Latitude of the Place.

3dly. It gives the Time of Day at Sea, when no other Instrument can.

4thly. It may be made as large and consequently as accurate as is desired.

A BC (Fig. 1.) represents part of the Hemisphere of a large Globe (half the Globe, and the Part below the Tropick are cut off, that it may take up the less Room). AC, half the Equator, divided into 12 Hours above, and 180 Degrees below, and subdivided into Minutes, as is likewise the lower Tropick DD; EE, a moveable graduated Meridian, turning on the Axis FF. G an Index to fix it (by the means of the Screw H) to any Hour. I i I, a circular beam Compass, the Center I i to be fixed on the Meridian to any Degree and Minute of Declination, by the Method commonly called *Nonius's* Divisions: k the Point for drawing Arches, which is likewise fixed to any Degree and Minute by the same Method. As the Meridian is at some Distance from the Globe, L is a piece of Brass to fix on the Meridian, marked with *Nonius's* Divisions, with a Point reaching down to the Intersection of the Arches, by which Means the Distance of the said Inter-

G section

section from the Equator, or it's Latitude is found. The Degrees and Minutes may likewise be shewn by diagonal Lines.

Prop. I. From two Observations of the Height of the Sun, the Distance of the said Observations in Time, being given by a Watch, as likewise the Declination of the Sun; to find the Latitude of the Place, and Hour of the Day.

I. When the Ship is at Rest, that is, at Anchor, or in a Calm, so as to have little or no Progressive Motion.

Case I. Suppose the Sun in the Equator, on the Day of Observation: Fix the Centre of the Beam-Compass at o Degree (or at the Equator,) and move the Point *k* to the Zenith Distance, (the Complement of the Altitude, taken by the usual Instruments,) and from any Hour, as from *C*, describe an Arch of a Circle with the said Point, as *bc* (*Ex. 1.*) Suppose eight Hours after, by your Watch, you have another Observation; move the Meridian eight Hours farther, to *d*, and fix it there; and with the Zenith Distance then observed, describe another Arch as *ef*, the Point where it cuts the former is the Place of Observation, and its Distance taken on the Meridian from the Equator, shews its Latitude; and the Minutes reckoned on the Equator from the
Meridian

Meridian to C and *d* (the Times of Observation) shew what those Hours were.

Case II. When the Sun has Declination : Fix the Centre of the Beam-Compass on the Meridian, to the proper Degree of Declination for the Day of Observation, and proceed as before.

Case III. If the Observations are at a greater Distance than twelve Hours, but in the same Day : Make use of the Complement to twenty-four Hours of the Distance in Time, and take the Declination on the contrary, or lower side of the Equator ; and instead of the Zenith Distance, take the Nadir Distances or Altitudes increased by 90° .

Thus you will find the Latitude, and Time of each Observation from Midnight. In this Case the Beam-Compass must extend to more than 90° .

Case IV. If the Observations are more than a Day asunder ; as for Instance, a Day and 2 Hours (26 Hours) : Place the Center of the Beam-Compass 2 Hours farther than it was the Day before ; but in different Declinations, according to the Table of Declination for the several Days.

Case V. When the Observations are made by a Star : The Centre of the Beam-Compass must be set to the Declination of the Star ; then proceed as before. To find the Hour in this Case, the right Ascension must be likewise given.

Scholium. The same Method may be useful at Land, when no Meridian Observation offers.

II. *The Ship in Motion.*

Case I. Suppose the Sun in the Equator : The Distance between the two Observations 8 Hours, as before, and the Arch aaa (*Ex.* 2.) described by the Zenith Distance of the first Observation, from the Centre C ; and the Angle cab , 40 Degrees, is the Angle between the Ship's way, and the Azimuth of the Sun continued, (given by the Azimuth Compass) and that during the eight Hours, the Ship has made 1° , or $60'$ from a to b , or from the Sun; then, as Radius is to the Cosine of cab 40° , so is ab $60'$ to ac $46'$; add $46'$ to the Zenith Distance Ca ; and with k , the Point of the Beam-Compass set at that Distance, describe the Arch cbe ; then with the Zenith Distance of the last Observation, whose Centre is d , draw the Arch ff ; the Point where it cuts the Arch cbe , is the Place where the Ship was last; and its Distance taken on the Meridian from the Equator shews its Latitude; the Minutes reckoned on the Equator from the Meridian to d (the Time of the last Observation) shew the Hour, or its Distance from 12 o'Clock.

Case II. If the Ship had sailed from a to β or towards the Sun: The Cosine of the Angle $\beta a \gamma$, or of the Angle between the Ship's

Ship's Way and the Sun, must be subtracted from the Zenith Distance of the first Observation.

N. B. Only the two Arches *cbe*, *ff*, are to be drawn on the Globe, the rest being added here, to shew the Reason of the Construction.

Case III. To find the Latitude of the first Place: From the Equator, with a Pair of Compasses, take the Distance sailed $60'$, and with one foot in the Intersection of the Arches *be*, *ff*, the Place found before, put the other in the Arch *aaa*, the Zenith Distance of the first Observation, and in this Instance, on the left Hand of the Azimuth of the Sun, this is the Place sought; and its Distance taken on the Meridian from the Equator, shews the Latitude; and the Minutes reckoned on the Equator from the Meridian to *C*, the Time of the first Observation, shew the Hour.

The Interval in Time or Degree between the two Places, shewn by the Index *G*, is the Difference of Longitude.

N. B. Those Observations are best, whose Arches cross each other almost at right Angles.

Prop. II. *The Zenith Distances of two Stars, observed at the same Time, their Declination, and right Ascension being known;*

to

to find the Latitude of the Place of Observation.

Fix the Center of the Beam-Compass to the Declination of either of the Stars, and with the Zenith Distance of that Star describe an Arch; move the Meridian as many Hours farther as is the Difference of right Ascension of the other Star; and fix the Centre of the Beam-Compass to the Declination of it; and with its Zenith Distance cross the first Arch: The Intersection shews the Latitude of the Place of Observation; and also the Distance of the right Ascension of the Zenith from that of either of the Stars, by which means the Hour may be known.

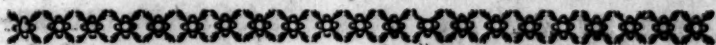
If a Celestial Globe is made use of, then place the Centre of the Beam-Compass over the several Stars.

The Latitude and Hour being given, the Variation of the Compass is easily known.

N. B. In order to draw Arches on the Globe; rub some black Lead powdered on a Piece of Paper; lay the Side which is blacked next the Globe, where you imagine the Intersection of the Arches will be: Then draw them on the clean side with the Point of the Beam-Compass, and they will appear on the Globe; and if the Globe is well varnished, they may be rubbed out with Bread, or washed out with Water.

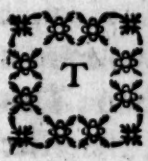
As

As Altitudes at Sea are now readily taken, with great Exactness, by *Hadley's Quadrant*, and as the said Altitudes are the Principles on which the Operations above described are founded; the previous Use of that Quadrant cannot but be of the utmost Importance to those who shall have Occasion for this Instrument; [for which, see my *THEORY of Hadley's Quadrant* demonstrated.]



SECTION IV.

The Use of the GLOBE in finding the true Distance of the MOON from the SUN or a STAR, by the observed Distance, allowing for REFRACTION and PARALLAX.

 **T**HE Globe is an Instrument equally applicable for finding the true Distance of the Moon from the Sun or Star, from the observed, or apparent Distance, taken by the *SEA-OCTANT* in the Problem of *finding the LONGITUDE*, or *Difference of MERIDIANS*, between any two Places. For the Degrees upon the Globe of 28 Inches Diameter, are larger than those upon

upon the Octants of the usual Size; and therefore by means of the *Nonius*, the true Distance may be had to as great an Accuracy, at least, as the observed Distance itself; and to pretend to greater Precision than the *Data* will admit of, is absurd; and will in vain be sought after; even from Calculations themselves.

To illustrate this Matter, we must explain by a Scheme the Doctrine of *Refraction* and *Parallax*, and the Difference between the *Apparent and true Places of Objects*, therefore (in Fig. 2.) let C be the Centre of the Earth AB; and B the Place of a Spectator on its Surface, whose Zenith is Z. And let N and n be two Places of a *Planet*, in an Azimuth Circle ZO; draw BN and CN, as also Bn and Cn; then are the Angles BNC, and BnC, the *Parallaxes* of the Planet at the Altitudes NO, nO, that is, if DG represent the Sphere of the Stars, a Spectator at the Center C, will view the Planet at N, among the Stars at F; and the Spectator on the Surface at B, will view it at E; and the Difference of these two Places E, F, in the Starry Firmament is the *Parallax* of the Planet, and is measured by the Angle $BNC = ENC$.

Now from the Principles of plain Trigonometry, we have $BC : CN :: \text{Sine of } BNC : \text{Sine of } NBC = \text{Sine of } NBZ$. Also $BC : Cn :: \text{Sine of } BnC : \text{Sine of } CBn$

$CBn = \text{Sine of } nBZ$, therefore (since $Cn = CN$) we have the Sine of $BN C : \text{Sine of } BnC :: \text{Sine of } ZBN : \text{Sine of } ZBn$. But in small Arches, or Angles at N and n , the Arches and the Sines are equal. *Whence the Parallatic Angle at N is to that at n , as the Sine of the Planets Distance from the Zenith ZN , to the Sine of the Zenith Distance Zn .*

Hence the following Corollies. (1.) If the Distance of the Object, or CN , be indefinitely great, the *Parallax will be insensible*, as in the Case of the Stars. (2.) If the Object be in the Zenith at Z , the Angle CNB , or the Parallax, vanishes. (3.) The Parallax is greatest of all when the Object is in the Horizon at M , 90 Degrees from the Zenith Z . (4.) The *Horizontal Parallax* BMC is greater or lesser as the Distance CM becomes less or greater. (5.) The *Horizontal Parallax* at M is to the Parallax at any Altitude N , as *Radius CM to the Sine NH of the Zenith Distance*. (6.) The Distance of the Planet (CN) is to the Semi-diameter of the Earth (BC) as the Sine of the Zenith Distance, to the Sine of the Parallax, or *as the Radius to the Horizontal Parallax*. (7.) The *apparent Zenith* of the Planet among the Stars is GE and the *True Zenith Distance* is GF ; always less than the apparent.

In like Manner may be explained the Effect

fect of the Atmosphere in refracting the Rays of Light. Let AB (Fig. 3.) be the Surface of the Earth, C its Center, B the Place of a Spectator; MNZ the upper Part of the Atmosphere, F any Celestial Object; FN a Ray of Light falling upon the Atmosphere in N, but is by the encreasing Density of the Air, gradually refracted into the curved Line NB to the Eye of the Spectator; let BE touch the Curve in B, and E will be the apparent Place of the Object F among the Stars, by the Laws of Optics.

Hence it appears (1.) That the *apparent Zenith Distance* GE is always less than the *True Distance* GF. (2.) The Object in the Horizon at O, will be most elevated by Refraction. (3.) An Object at the Zenith G suffers no Refraction at all. See my NEW ELEMENTS of OPTICS for more upon this Subject.

The Application of this *Doctrine of Parallax and Refraction* in finding the Longitude at Sea, by Means of the Celestial Globe of 28 Inches Diameter, will not be difficult. For this Purpose the Altitude or Zenith Distance, of the Moon, and of the Sun or Star at a given Instant, must be carefully taken with a Sea-Octant, as also the Distance between them; and from these Measures of the *apparent Distances*, and the given Quantities of Parallax and Refraction at the respective Altitudes, the true Distance and Places of

of

of the Moon and of the Sun or Star may be found upon the Surface of the Globe, furnished with the following simple, and easy Apparatus, *viz.*

First; An *artificial lunar ORBIT*, which may be most commodiously constructed with a filken String or fine Cord, and properly rectified to the present Month.

Secondly; Two *moveable graduated vertical Circles* to be fixed to any two opposite Points of the general Meridian, or the *Zenith* and *Nadir* of the Place of Observation.

Thirdly; A *graduated Measuring Arch*, furnished with a *fixed and moveable Nonius* for measuring Distances *to a Minute*, with Ease. Then to represent the Process, let H Z O (Fig. 4.) be the Brass Meridian, Z the Zenith; A the apparent Place of the Moon; E A her Altitude, or Z A the apparent Zenith Distance taken by the Quadrant. Also let B be a Star, whose apparent Altitude is BF, or Zenith Distance Z B; then of Course A B will be the apparent Distance between the Moon and Star, all measured as exactly as possible by the Quadrant at the same Time.

Now by a Table of *Refractions* (which you find in my *THEORY OF HADLEY'S QUADRANT*) the Refraction for the Altitude FB is known, which is B*, and to be subducted from the apparent Altitude FB, and there will be had the true Altitude F* of the

Star. The Place of the Star, truly corrected upon the Globe, will coincide with the Point * of true Altitude in some Position of the Vertical ZF, which is easily found upon Trial.

Then by the same Table the *Refraction* is found for the apparent Altitude of the Moon AE; but besides this, the Quantity of *Parallax* must also be sought for the said Altitude, (and which is always to be had in every Set of *Astronomical Tables*.) But as the Refraction encreases the Altitude, and the Parallax diminishes it, the Difference between both must be taken, and added to the apparent Altitude AF, and this will give the true Altitude of the Moon EC.

This being obtained, set the Index of the fixed *Nonius* to the apparent Place of the Star B upon the Vertical ZF, and carry the measuring Arch to the other Vertical, and move them both in such Manner, that the apparent Altitude EA, and measured Distance BA, may both coincide at A. This gives the true Position ZE of the Moon's Vertical; then, every Thing being rightly ordered, the true Place of the Moon γ will fall upon its proper Orbit; and the true Distance between the Moon and Star, viz. γ^* , will be found for the Time of the Observation, by the measuring Arch, and its *Nonius*, to a Minute.

If the Distance of the Moon from the Sun be taken, let that be AD ; then pursuing the same Method as before, you get the true Distance \odot at the Time and Place of Observation. As these apparent Distances are taken between the Limbs of the Luminaries, Allowance must be made for their Semi-diameters at that Time, that the true Distance of their Centers may be known also.

Then for the *same Moment of Time* let the Place of the SUN and MOON be calculated for the Place you would know the Longitude from, as LONDON, PARIS, &c. By this Means you have the Difference of the Moon's Place in her Orbit, at those two (really different) Moments of Time; and then finding the Moon's *Hourly Motion*, you find thereby the Time required for the Moon to pass through that Arch of Difference, which Time is the *Difference of Longitude sought*, when converted into Degrees, as directed Page 42, of the USE of the GLOBES.

The Instrument for taking the Distance of the Moon from the Sun or Star, is *Hadley's Octant*, the only one, indeed, adapted for such an Use, but as they are usually made, they can be applied only in the first and last Quarters of the Moon in measuring her Distance from the Sun; and her Distance from a Star more than 90 Degrees, cannot be taken. There is therefore a considerable Defect,

fect, yet remaining in the Instrumental Part of this famous Problem.

It is to remedy this, that I have proposed to construct this Instrument with two Indexes, *viz.* one for *Degrees*, and the other for *Minutes* of a Degree; so that by Means of both, you measure any Arch or Angle to 180 Degrees, which is the greatest of all; and this without any Addition to the Bulk of the Instrument, which is rather less in this, than in the usual Form, and equally easy to be applied for measuring any Distance between the Moon and the Sun or Star.


I shall only observe further on this Head, that my New GONIOMETER may be applied to the *Nautical TOP*, for taking *ALTITUDES* of the *SUN* at *SEA*, instead of *Hadley's Quadrant*; and thus the *Multiple Angle* of Altitude, will be true in *Seconds*, when the common Method (of measuring the Angle at one) rarely gives it to a *Minute*.

SECT.



SECTION V.

*The Rationale of the METHOD of
correcting the PLACES of STARS,
when necessary, upon the Celestial
GLOBE.*

 T has been shewn (Page 100, &c.) that by the Retrograde Motion of the Equinox, the Stars have all an apparent Motion *in Consequentia*, i. e. from *West to East*, at the Mean Rate of *one Degree in 72 Years*, or *50" per Ann.* The Consequence of which is, that the Longitudes or true Places of the Stars will be constantly altering in the Heavens, and therefore cannot long agree with their Places upon the Surface of the Globe. Also their *Right Ascension, Declination, Altitudes, Azimuths, Amplitudes, &c.* will in a Course of Years be sensibly variable; and therefore require to be rectified for the Uses of GEOGRAPHY, ASTRONOMY, and NAVIGATION, &c. about every 20 Years.

But

But before we give the Rules, we shall shew how, and from whence they are derived; and the Reader may find the Demonstration of the Whole at large in Vol. II. of my *Mathematical INSTITUTES*, Page 253, &c. Therefore let HZQ , (Fig. 5.) be the Meridian, Z the Zenith, HO the Horizon, P the Pole of the Ecliptic EQ , and N the Pole of the Equator $ÆQ$. Also let A be the Place of a Star, NAB a Circle of *Declination*, and PAC a Circle of *Latitude*.

Then in the Ecliptic, C will be the Star's Place or Longitude, and let its *annual Variation* be $Cc = 50''$, through A draw eAg parallel to the Ecliptic EQ , and draw the dotted Circle of Latitude, cP , cutting the Parallel eq in (a) which will be the Star's Place in its Parallel after one Year, and its Change of Place, or Motion in *Consequentia*, will be Aa .

Again, in the Equator $ÆQ$, the Alteration in the Star's *Right Ascension* will be Bb ; and that of its *Declination* will be $AB - ab$. Now as A and a may be considered as two different Stars in the same Parallel of Latitude cq , 'tis evident what ever relates to the *Altitude*, *Azimuth*, *Amplitude*, *Hour-Angle*, &c. of two such Stars, will be the same in regard to the two different Places A and a of the same Star, by its Motion in *Consequentia*.

The

The LONGITUDE and LATITUDE of most of the noted Stars, especially those about the Zodiac, the late ABBE De la CAILLE has given us, in his *Fundamenta Astronomiæ*, corrected to the Year 1750. By which it will be easy to find the *Longitude*, *Declination*, and *Right Ascension*, of any of those Stars, and consequently their true Places upon the Globe, for any Year proposed, by the following Rules and Examples.

Let the Longitude of *Sirius* be required for the Beginning of the Year 1767. Then in the Table the Longitude of that Star was in ♄ , $10^{\circ} 38' 22''$, at the Beginning of the Year 1750; and in 17 Years, the Motion in Longitude is $17 \times 50'' = 850'' = 14' 10''$ which added to the above Longitude, makes $\text{♄ } 10^{\circ} 52' 32''$ for its Longitude required.

To find the annual Alteration in Declination of any given Star, as *Regulus*, or the Lion's Heart; the Analogy to be used, requires the Star's Right Ascension from the *Solstitial Colure*, or Angle ÆNB to be known. Now the Right Ascension of *Regulus* being $148^{\circ} 51' 6''$, if you deduct 90° , there will remain $58^{\circ} 51' 6'' = \text{Angle at N}$; and putting the Obliquity of the Ecliptic $= 23^{\circ} 29'$, say

I

As

As Co Sine of $76^{\circ} 49'$ $AN = 23^{\circ} 29'$ 10.397591

To the Sine of the Angle $N = 58^{\circ} 51'$ 9.932456

So is the Precession $Aa = 50''$ 1.698970

$10.488000 = 94^{\circ} 07' = NA$ 11.631426

To the Alteration in Declination $17^{\circ} 23' 38''$

From hence it appears, that the Variation in Declination is proportioned to the Sine of the Star's Distance from the Solstitial Colure only; therefore those Stars in or near that Colure, have the same Declination for many Years together; but those in or near the Equinoctial Colure, suffer the greatest Change of Declination.

To find the Annual Alteration in Right Ascension, the Angle at A must be known; and for that Purpose in the oblique Triangle ANP, there is given (for *Regulus*) $AN = 76^{\circ} 49'$, the Co-Declination; the Angle at P $= 56^{\circ} 21'$, the Longitude from the Colure; and $PN = 23^{\circ} 29'$ the Obliquity of the Ecliptic; to find the Angle at A, say

As the Sine of $AN = 76^{\circ} 49'$ 9.988491

To the Sine of the Angle at P $= 56^{\circ} 21'$ 9.920352

So is the Sine of $NP = 23^{\circ} 29'$ 9.600469

19.526761

To the Sine of the Angle $A = 19^{\circ} 55'$ 9.532360

Then

Then to find *Bb*, the Alteration in Right Ascension, say,

As the Sine of — AN = $76^{\circ} 49'$ = 9.988401

To the Co-tangent of A = $19^{\circ} 55'$ — 10.440903

So is the Variation in Declination 17" — 1.231835

11.672738

To the Variation in Right Ascension 48" — 1.684337

By having the annual Variations, you find the true Places of the Star for any Year proposed; and thus they have been found and tabulated for all the principal Stars, according to the following Specimen for STARS of the first Magnitude, adjusted to the Year 1760, N^o 6.

Names.	Right Ascension.	Ann. Vari.	Declination.	Ann. Vari.
ALDEBARAN	65 32 36	51	16 0 47N	+ 8
CAPPELLA	74 44 53	66	45 43 34N	+ 5
RIGEL	75 45 23	43	8 29 46S	- 5
α ORION	85 32 49	49	7 20 31N	+ 2
SIRIUS	98 38 45	40	16 24 5S	+ 3
PROCYON	111 40 57	48	5 49 29N	- 7
REGULUS	148 53 28	48	13 8 0N	+ 17
α VIRGINIS	198 8 47	47	9 54 1S	+ 19
ARCTURUS	211 11 2	42	20 26 48N	- 17
ANTARES	243 41 4	55	25 52 36S	+ 9
The LYRE	277 12 7	30	38 34 26N	+ 2
The EAGLE	294 46 2	44	8 15 9N	+ 8
FOMAHAUT	341 5 3	50	30 53 12S	- 19

It is evident from the Figure, that in the first and third Quarters of the Ecliptic, the *North Declinations* encrease, and their Variations are *affirmative*, or to be *added*; but in the second and fourth Quarters, they are *Negative*, and to be *subtracted*; and *vice versa* in Stars of a *Southern Declination*.

The retrograde Motion of the Equinox can make no Alteration in the *Latitude* of Stars, because the Equinoctial Point is always in the Ecliptic, and consequently the Motion *in Consequentia*, in every Star, is in a Parallel to the Ecliptic. But it happens, that on Account of the attracting Forces of the Planets, the Ecliptic itself is not *stable*, or constantly in the same Position with respect to the Equator, and therefore neither the *Obliquity of the Ecliptic*, nor the *Latitude of Stars* can continue precisely the same; yet the Variation in 100 Years does not amount to any sensible Quantity, (*viz.* about 40 Seconds more or less) and therefore can make no Alteration of their Places upon the Globe.

It is evident from the Figure, that in the first and third Quarters of the Ecliptic, the

in the second and fourth Quarters, they are
SECTION VI.

The ancient Canicular ASTRONOMY.

explained upon its proper PRINCIPLES, and illustrated by CALCULATIONS.

THE *HELIAL* RISING and SETTING of the SUN was omitted among the Problems of the Stars, we shall here supply it, especially as the Doctrine of the *Canicular ASTRONOMY* (concerning which the learned BAINBRIDGE wrote a Treatise) depends entirely upon it.

A Star is said to *rise Heliacally*, when it is at a sufficient Distance from the Sun to be first seen distinctly in the Horizon at its *Rising* in the Morning; and it *sets Heliacally* when it ceases to be seen in the Horizon of an Evening after *Sun-set*. It has been found by *Ptolemy*, and other Astronomers, that the Distance of the Sun below the Horizon, is then about 12 Degrees, for a Star of the first Magnitude.

Therefore to find the *Helical* rising of a Star, bring it to the eastern Part of the Horizon,

zon, and lay the Quadrant of Altitude over the western Part of the Globe, and there move it so that the 12th Degree may cut the Ecliptic; mark that Point in the Ecliptic, and the Point opposite to it, is that in which the Sun is 12° below the Horizon, when the Star rises, and the Time of the Year corresponding thereto, is found in the Calendar upon the Horizon. In the same Manner you find the Time when the Star sets heliacally.

It is supposed, the ancient Egyptians took this Method of observing the Moon, in order to get some Idea or general Measure for MONTHS; hence, they concluded, that the Time between two heliacal Risings of the Moon (or between two New Moons, as they are now called) was 30 Days, and accordingly they divided their Year into 12 equal Months of 30 Days each; this was called the Luni-Solar YEAR; and consisted of 360 Days.

But having learned by continued Observations on the Heliacal rising and setting of Stars that the true Length of the Year exceeded 360 Days, by about 5 Days, they added these 5 Days to the End of the Year, which then consisted of 365. These additional Days were afterwards called Epagomenæ by the Greeks.

Because the Egyptians in these Observations made use of the Sirius (the Dog Star) this Year of 365 Days was called the

Cani-

Canicular Year. As Astronomy farther advanced, it was soon observed that this Year was deficient of the Length of the natural Year by about 6 Hours, or a Quarter of a Day; for by that Space of Time they found the *heliacal Rising* of *Sirius* was later and later yearly. Therefore in 4 Years the Star rose one Day later, and in 4 times 365, or 1460 Years it rose a whole Year later, that is, in the Compass of 1460 Years, *Sirius* would rise heliacally upon the same Day of the Month.

This Space of Time was by the *Egyptians* called the *Sothiacal Period*, because the Name of *Sirius*, with them was $\Sigma\theta\theta$, *SOOTH*. And of Course, 1460 Solar Years were equal to 1460 of the *Egyptian* Civil Years; the first Month of which was called *Thoth*, and Corresponded to *September* in the *Roman Calendar*. And it is to be supposed that the Beginning of the *Sothiacal Period* was at the *Heliacal Rising* of *Sirius* on the first Day of *Thoth*, or the Beginning of the *Egyptian Year*.

Mr. BAINBRIDGE illustrates this Matter by the following Scheme, (Fig. 6.) Let *SZ* be an Arch of the eastern Horizon, *OZ* a Part of the *Ecliptic*, and *S* the Place of the Star (*Sirius*) at its Rising. Let the Sun be rising at the same Time in *Z*, by his Light obscuring the Star at *S*. Now that the Star may be visible at Rising, it is required that the

the Sun be at some certain Distance from the Star, below the Horizon, and let that Distance be $Z\alpha$; so that when the Sun is in α or lower, the Star rising at S will be visible, but if the Sun be any-where between Z and α , it will not appear at rising.

From α towards Z, take the Arch $\alpha\epsilon$ equal to a Quarter of a Degree; and on the other Side, take $\alpha\delta = \beta\gamma = \gamma\delta = \alpha\epsilon$; and the Motion of the Sun through a Quarter of a Degree is made in 6 Hours nearly, which is the Excess of the Tropical Year above the *Egyptian Year* of 365 Days.

These Things premised, it follows, that on the first Day of *Thoth*, in the *first Year*, SIRIUS at S is rising and visible when the Sun is at δ ; the *second Year*, on the same Day of *Thoth*, the Sun will be at γ ; in the *third Year*, on the first of *Thoth*, when he is at β ; and the *fourth Year* still on the first Day of *Thoth*, when he is at α ; for at the End of every *Egyptian Year*, there was wanting to compleat the tropical Year, a Quarter of a Day; and to finish the Sun's Course, a Quarter of a Degree.

During these first 4 Years, then, when the Sun is in $\delta, \gamma, \beta, \alpha$, the Star rising at S will be visible on the first Day of *Thoth*. But in the 5th Year, on the first Day of *Thoth*, the Sun will be at ϵ , and the Star rising at S, will not be seen; but on the second Day of *Thoth*, the Sun will be in δ ,
and

and the Star rising at S will be visible. In the *sixth Year*, on the same second Day of *Thoth*, the Sun will be in γ ; the seventh Year in β ; and the eighth Year in α . So that during these second four Years, the Star S will rise Heliacally visible on the second Day of *Thoth*. And after the same Manner it is shewn, that during the next four Years, the Star will rise and be visible on the *third Day*; and for the next four Years, on the 4th Day of *Thoth*; and so on, till it has passed through all the Days of the Year.

Having thus explained the Nature of the *Canicular Year*, and *Sothiacal Period*; Mr. BAINBRIDGE next proceeds to an *astronomical Solution* of the following Problem, *viz.* For any given Time and Latitude of a Place, to find the *Heliacal Rising* of any given Star.

In order to the Solution of this Problem, the *Longitude* and *Latitude* of the Star, as also its Right Ascension and Declination, are to be taken from Astronomical Tables; from thence we find the *Ascensional Difference*, and oblique Ascension; and these being known, we find the Point of the Ecliptic rising with the Star, and the Angle contained between the Ecliptic and Horizon; and then, lastly, by these *Præcognita*, we find the Sun's Place in the Ecliptic, in the *heliacal Rising* of the Star.

Having constructed a proper Scheme, (Fig. 7.) for *Heliopolis* in lower Egypt, we can

K

thereby

thereby illustrate the Process of astronomical Calculation; for therein let HZ OQ be the Meridian; HCO the Horizon; P the North Pole; OP the Elevation thereof, or Latitude of *Heliopolis*; Z the Zenith. ÆCQ the Equator; EAL the Ecliptic; \sphericalangle the Autumnal Equinox; S the Place of *Sirius* in the Horizon rising heliacally; PSM a Circle of Declination; ISR a Circle of Latitude; N the South Pole of the Ecliptic. ZST the vertical Circle through *Sirius*. D the Place of the Sun at the heliacal Rising of the Star, to find which is the general Problem proposed.

Therefore let the Example be *to find the heliacal Rising of SIRIUS at Heliopolis in the Year 1750.* The Latitude of *Heliopolis* is $\text{ÆZ} = 30^{\circ} 22'$; and the Declination of *Sirius*, is $\text{SF} = 16^{\circ} 23' \frac{1}{2}$; therefore in the Right angled Triangle SFC, say (by Case II. Page 192 of the Use of the GLOBES.)

As the Tang. of the Angle SCF = $59^{\circ} 38'$ — 10.232165

Is to the Tangent of SF = 16 23 — 9.468589
So is Radius ————— 90 10.

To the Sine of the Arch CF = 9 47 — 9.236415

To the Right Ascension of *Sirius* for 1750, viz. $98^{\circ} 32'$, add the Ascension Difference now found, and the Sum will be $108^{\circ} : 19' =$ oblique Ascension of *Sirius*.

The

The next Thing to be determined is the Point of the Ecliptic A rising with *Sirius* S, to find which there is given in the oblique Triangle $C \triangle A$, the Obliquity of the Ecliptic or Angle at $\triangle = 23^\circ 28'$; the Angle $\triangle C A = 59^\circ 38'$, the Co-latitude; and $C \triangle$, the Supplement of Oblique Ascension (just now found) $71^\circ 41'$ to find the Side A \triangle .

In order to this, from the Point C let fall the Perpendicular $C a$, then in the right angled Triangle $C \triangle a$ there are known the Hypothenuse $\triangle C$, and the Angle \triangle to find $C a$; say (by Case III.)

As Radius	_____	_____	10.
To the Sine of $\triangle C =$		$71^\circ 41'$	9.977419
So is the Sine of $C \triangle a =$		$23^\circ 28'$	9.600118
To the Side $C a =$		$22^\circ 12'$	9.577537

Then you find the Angle $\triangle C a$ (by Case III. Anal. 3.)

As Co-sine of $\triangle C =$	_____	$71^\circ 41'$	9.497301
Is to Radius	_____		10.
So is the Co-tangent of \triangle		$23^\circ 28'$	10.362389
To the Tangent of $\triangle C a =$		$82^\circ 14'$	10.865088

Then from $82^\circ 14'$ take $59^\circ 38'$, there will remain the Angle $A C a = 22^\circ 36'$.

In the right angled Triangle $\triangle C a$ we find the Base $\triangle a$, by saying,

As Radius	—	—	10.
To the Sine of $\triangle C$ =	—	71° 41'	9.977419
So is the Sine of $\triangle C a$ =	—	82 14	9.995998
<hr/>			
To the Sine of $\triangle a$ =	—	70 9	9.973417

In the right angled Triangle $A C a$, there are known the Side $C a$, and the Angle $A C a$; to find the Side $A a$ (by Case I. Anal 1.) say,

As Radius	—	—	10.
To the Sine of $C a$ =	—	22° 12'	9.577537
So is the Tangent of $A C a$ =	—	22 36	9.619364
<hr/>			
To the Tangent of $A a$ =	—	8 56	9.196901

Then from 70° 9' (= $\triangle a$) take 8° 56', there will remain 61° 13' = $\triangle A$; which taken from 180°, will leave 118° 47', or \angle 8° 47', for the Point of the Ecliptic A rising with *Sirius* at S .

To find the Angle at A , say,

As the Sine of $A a$ =	—	8° 56'	9.191130
<hr/>			
To the Sine of $A C a$ =	—	22 36	9.584665
So is the Sine of $C a$ =	—	22 12	9.577537
<hr/>			
			19.162202
<hr/>			
To the Sine of $C A a$ =	—	69 19	9.971072

Lastly; in the right angled Triangle $A B D$, there are known the Angle $B A D$, last found, and the Side $B D$, the Depression of the Sun below the Horizon, which to render

render the very large and bright Star *Sirius* visible at S, in the clear and serene Air of *Egypt*, Mr. *Bainbridge* estimates at 11 Degrees.

Therefore say,

As the Sine of B A D = — 69° 19' — 9.971072

To the Sine of B D = — 11 00 — 9.280599
So is Radius ————— 10.

To the Sine of A D = — 11° 46' — 9.309527

To the Co-orient Point of the Ecliptic A = Ω 8° 47' add 11° 46', the Sum will be Ω 20° 33' for the Place of the Sun required, when *Sirius* rose heliacally in the Year 1750, which was on *Aug.* 3d. *Old Style*.

Now from *Aug.* 3. to *Sept.* 1. (or *Thoth*) when the *Sothiacal Period* begins, is 28 Days; therefore $28 \times 4 = 112$ Years yet to come of the Current Period; hence $1460 - 112 = 1348$, the Year of the Period for *An. Dom.* 1750. Also $1750 - 1348 = 402$ the Year of CHRIST, when the present Period began. Again $1460 - 402 = 1058$ the Year before CHRIST when the former Period began. And lastly $1750 + 112 = 1862$, when the *Sothiac Period* begins again.

Hence it appears that the learned *Bainbridge* was mistaken in fixing the first Year of the *Sothiac Period* to the Year of CHRIST 138, by following the uncertain Accounts of *Censorinus* and *Clemens Alexandrinus*. Also Mr. *Costard* has committed an Error in taking

taking the Arch A G of $57^{\circ} 34'$ instead of $27^{\circ} 34'$, and thence makes the present *Sothiacal* Period begin *A. D.* 375 which is 27 Years too early. See his first LETTER to MARTIN FOLKES, *Esq;* Page 34, &c. And *Bainbridgii Canicularia*, Page 34, 35. The Substance of his Book we have now nearly exhausted, and shall only further observe that when *Sirius rises heliacally*, those called the *Dog-Days* end, and they begin when this Star sets *heliacally*, i. e. when he is less than 12 Degrees from the Sun at his Setting; for during that Interval, this Star is above the Earth with the Sun, and because when the *heliacal Rising and Setting* were in the Beginning of the Month *Thoth*, these *Dog-Days* were very hot, it gave Rise to the superstitious Notions the Ancients had of the pernicious Influence of this Star on the Air, the Bodies of Animals, &c. But as they had no Intercalary Day, their *Dog-Days* in one *Sothiac Period* run through all the Months of the Year, whereas, with us, by Means of the Day added in *Leap Year* they are always in the *Autumnal Season*.

S E C T.

SECTION VII.

*An ABSTRACT of Mr. HORNSBY'S
ACCOUNT of the ensuing TRANSIT
of Venus, in 1769, and the best
Places for observing the same; to
which is subjoined an Account of a
New HELIOSCOPE to be used for
shewing the Phases of the Transit
to the greatest Advantage.*



IN my TREATISE of the TRANSIT
of VENUS over the SUN'S Disk,
printed in the Year 1761, the
Reader will find most of the Parti-
culars relative to the THEORY and CALCU-
LATION of such a *Phænomenon*; and whereas
the Observations on the Transit of Venus in
that Year, were not of much Use in deter-
mining the SUN'S PARALLAX; it is to be
presumed that the Transit of that Planet over
the solar Disk in the Year 1769, will be
thought worth a more mature and thorough
Attention; and though Literature seems now to
be in a manifest Decline, yet as such a Means
of determining the Solar Parallax, and in
Consequence of that, the Distances of all
the

the Planets from the Sun, and from each other, will not offer again in more than an 100 Years, there is no Doubt but such a fortunate Opportunity will be eagerly embraced by all who have it in their Power to contribute any ways towards improving the same ; and indeed it is no less than a Duty the present Age owes to Posterity, who must think themselves greatly disregarded, if an Age abounding with such Riches, learned Men, most accurate Instruments, and in short, every Thing necessary to ascertain the Dimensions of the Solar System, from two Transits (offered as it were on Purpose) were not to do this great Work for them. I need not mention what an eternal Disgrace it must reflect upon the present Generation, should they supinely let such a double Opportunity slip for promoting the Honour of the Sciences in general ; and in particular for advancing ASTRONOMY to the *Apex* of all its Glory.

As the Problem of exhibiting all the Phases of such a Transit, is one of the most noble and useful upon the Globe, I have been very circumstantial in giving Directions about it in the Treatise of the Globes, Page 140, &c. exemplifying the same for the said Transit in *June*, 1761 ; and also by a large Print of the same, to give the best Assistance I could for forming an Idea of such an interesting Affair. As these Problems will be the same for
any

any Transit ; it will be only necessary here, to state the Times of the Phases, and Duration of the Transit in 1709, which we have already done to our Hands by Mr. *Hornsby*, in a general Manner, from Dr. *Halley's* Tables of the Motions of *Venus*.

In Fig. 8 ABD is the Sun's Disk, C its Center, AN the Ecliptic, EN the apparent Path of *Venus*, K is the Place of *Venus* at the external Contact with the Sun's Eastern Limb, H her Place at the internal Contact with the same, HI her Passage over the Solar Disk, F her Place at the true Conjunction, and G at the Middle Moment of the Transit ; then the Particulars of the Transit are specified by the following Numbers.

	S.	°	'	"
The Mean Longitude of <i>Venus</i> in the Beginning of the Year 1769	0	5	23	48
The Place of the ascending Node	2	14	35	21
	d.	h.	'	"
The Ecliptic Conjunction, June	3	9	59	24
<i>Venus's</i> Geocentric Latitude CF			10	13 ⁵
Logarithm of the Earth's Distance from the Sun	5	0065	166	
Ditto of <i>Venus</i> from the Sun	4	8610	947	
Ditto of <i>Venus</i> from the Earth	4	4606	784	
Equation of the Precession of the Equinoxes	+	17	7	"
<i>Venus's</i> hourly Motion from the Sun in the Ecliptic	3	57	7	"
Ditto in the relative Orbit EN	4	1	0	3
Ditto in Latitude			35	45
L				The

The Angle of the Path with the Ecliptic	8 29 2
<i>viz.</i> ANE	
Angle of the Ecliptic with the Equator	7 2 54
Angle of <i>Venus's</i> Path with the Equator	15 31 56
Least Distance of the Centre CG	10 6 8"
Mean Time of the Middle of the Transit at <i>Greenwich</i> Observatory	10 21 45
Equation of Aberration in Longitude	55
Mean Time of the Middle of the Transit at G equated	10 20 50
Aberration in Latitude	1 35
Equated mean Distance of the Centres CG	10 8 15"
The Semi-diameter of the Sun	15 45"
Ditto of <i>Venus</i>	29
Interval of Time between the external Con- tact at K, and Middle at G	3 10 8 1/2
Ditto between internal Contact at H, and Middle of the Transit at G	2 51 13,2
Duration of the Ingress	18 34
	d. h. "
Time of external Contact, <i>June</i>	3 7 12 56
Of total Ingress	7 31 52
Middle of the Transit	10 23 4
Beginning of Egress	13 14 16
Last Contact	13 33 11

Such would be the Phenomena of the
Transit, without regard to Parallax, or view-
ed

ed from the Earth's Center. To the *British* Isles, and to the neighbouring Parts of the Continent, the Effect of Parallax is nearly at a *Maximum*; and will considerably accelerate the Times of the external Contact and Ingress. If the Sun's Parallax be supposed $8,7''$ the horizontal Parallax of *Venus* from the Sun will be $21,87''$. Whence the Times of the external Contact will be at $7^h 5' 47''$ more than an Hour before Sun-set, when the Altitude of *Venus* is about 8 Degrees. And the total Ingress will happen at $7^h 24' 40''$, the Height of the Planet 5 Degrees.

If the Sun's Parallax should be one Second larger, or $9,7''$, the Time of Ingress will happen at $7^h 23' 51''$. And for the Times above-mentioned the Phases of the Transit may be universally exhibited by the Globe in the Manner directed in the Body of the Book, Page 140, &c. for the Sun's Declination $22^\circ 26' 40''$, at that Time.

It is farther observed by Mr. *Hornsby*, that the joint Effect of the Parallaxes in Longitude and Latitude to lengthen the total Duration of the Transit will be greatest to those Places which are about 24° or 25° to the East of *Greenwich*, and in the 66th or 67th Degree of North Latitude, when the Sun's Altitude at each Contact is about 5 Degrees; as at *Tornea*°, *Kittis*, and the adjoining Parts of *Swedish Lapland*. But if the Sun's Altitude be required = 10, the

Latitude of Places under the same Meridian will be 73° or 74° as at *Wardhu*, &c.

At *Tornea* the first internal Contact gives $6' 33''$, and the second $4' 47''$, and the Sum $11' 40''$ is the Time by which the total Duration will be lengthened there.

On the other Hand, there are Places where the said Duration will be shortened as much as possible; and the Latitude of these Places are 54° South, and in 153° of West Longitude from Greenwich, when the Sun's Altitude is 3° , or in about 47° of South Latitude, when the Sun's Altitude is 10° .

On the Supposition that the Sun's Parallax is $= 8,7''$, the total Duration of the Transit in Latitude 55° will be shortened no less than $12' 53''$. The whole Difference therefore of the Duration of the Transit, in this Latitude, and at *Tornea*, is no less than $24' 33''$. A Difference considerably greater than was expected by Dr. HALLEY in the Transit of 1761.

Another very good Method of finding the Sun's Parallax at this Transit, is, by stationing two Observers in such a Manner, that one of the internal Contacts might be observed with the greatest Difference possible arising from a contrary Effect of Parallax at the two Places. This Method may be practised at both Contacts in 1769, but in this Way, the Longitude of the two Places must be rigorously known.

When

When the Sun's Altitude is 5° or 10° , then *Greenwich* and *Dublin* will be very advantageous Stations for observing the first internal Contact; and in South Latitude 46° , and West Longitude about 168° , will be the best Station for the last internal Contact, when the Sun's Height is 5° . But as these Parts lie in the great Pacific Ocean, where there does appear to be any Land, the nearest Islands must be made Choice of for that Purpose.

The last internal Contact or Beginning of Egress will be accelerated as much as possible, when the Sun has 5° Altitude, in about 19° of South Latitude, and 123° of West Longitude from *London*. And under the Tropic of Cancer, and in about 67° of East Longitude from *London*, the said Beginning of Egress will be most of all retarded. But as many Degrees Difference in Longitude and Latitude will not make much Difference in Parallatic Time, so a large Scope will be left for chusing Places most advantageous for this Purpose.

As both these Methods may be practised in many Places, they will mutually confirm and illustrate each other. Thus far from *Mr. Horneby*.

As to the Instruments for observing the Phases of the Transit, they are of the Telescopic Sort; but those which shew them by reflected Light without any Refraction thro' Glasses

Glasses at all, are most certainly the best; this may be done by a reflecting Telescope by two Reflections; and the Image of the Sun and the Planet will be extremely distinct, and the external and internal Contacts may be observed very critically without the Fatigue of poring through the Telescope as in the common Way of looking at the Sun, where a dark Glass must be used, besides the two Eye Glasses, all which tend to render these Observations less perfect and accurate.

The above Method when the Sun has about 5° of Altitude will do very well, as it makes the Sun's Image from six to twelve Inches diameter, or more (if required) when the Room is large. But a HELIOSCOPE may be constructed for this Purpose, which shall give an Image of the Sun, by reflected Light only, of 24 Inches Diameter, and that of the Planet *Venus* $\frac{1}{4}$ of an Inch, in so small a Space as 3 Feet by 2. This curious Contrivance I often use for viewing the Sun's Face and Spots, as also for shewing small Objects in vastly large Images, by reflected Light, and therefore without Colours. Such a Method could want no Recommendation to the Curious, if they were but acquainted with its Merit; for which they may consult my *OPTICAL ESSAYS*, Page 39. The HELIOSCOPE here mentioned being only one of the many Uses of the *Universal PERSPECTIVE* there described.

F I N I S.

POSTSCRIPT.

Should not have thought it worth my While to take Notice of any Thing said by the *Critical Reviewers* relative to my Writings, but that I think a few Lines will be very necessary to apprize the Public how far they may think they have any Reason to be biased in Favour of, or prejudiced against any Book, by any of their Criticisms upon it.

A few Years ago, a worthy and learned Friend of mine died, and his Widow published a Treatise of some very curious Mathematical Subjects contained in XXV Propositions which her Husband had left behind him. One of these Propositions, only, was faulty, and wholly so; but the *Critical Reviewers* purposing to serve the Widow and Orphans, as far as lay in their Power, first employed a great deal of parrotic Eloquence to recommend the Performance, and to enforce it, decorated very sagely on the Novelty, Ingenuity, and Utility of the *Tangential Sea Chart* proposed by our Author in the XXIInd Proposition above referred to. Now the Construction of this Chart was so widely different from that of *Mercator*, and every Way so false and unfit for any *Nautical Purpose* whatever, that it may fairly be presumed not a *Tyro* in *Nautics*, or a single Person in the Nation besides the *Reviewers*, who makes the least Pretence to any Skill in the Theory of Navigation, could have made so scandalous a Blunder as publicly to approve, applaud, and recommend the Book on the supposed Truth and Excellency of that Invention!

Such is the Tribunal, at which the Merit of Authors is to be tried and decided. These are the Judges in *Nautical Science*, who censured my *New PRINCIPLES of GEOGRAPHY and NAVIGATION*, founded upon the New discovered Figure of the Earth, only because I could not tell which came nearest the Truth, the Charts constructed upon the Numbers resulting from the Degree measured under the Arctic Circle as given us by *Madriperius*, or the Tables of *Don Juan* derived from the Measure of a Degree under the Equator; and therefore my great Crime was to give them both, that the practical Navigator might have in his Power to use either of them as he pleased, as they differ exceeding little from each other, and yet each comes very near the Truth, at least much nearer than the common Table of *Meridional Parts*, or *Mercator's Charts* do.

These

P O S T S C R I P T.

These are the *Connoisseurs* who now undertake to inform the Publick what Opinion they should entertain of my *Institutions of astronomical Calculations*, but I believe the Mathematical Part of the Publick are too well acquainted with, and too good Judges both of their Writings and mine, to think themselves in the least obliged to them for their *profered Service*. This Work, they inform the World, is a *Translation*, which I did not know before; I never called it any Thing more than an *English Edition* of Mr. CLAIRAUT'S Tables of the *Lunar Motions*, with an Explication prefixed.

The 13th and 14th Chapters, they advice me to expunge in a second Edition, and why? because I have made Use of *absurd Properties of Circles and Ellipses* instead of the *Radius of Curvature*. I suppose this to be the first Time the Public ever heard that Circles and Ellipses had any *absurd Properties*——If they have none, I have made Use of none.

The Truth is no more nor less than this, my Design was to shew the true Quantity of the Phases of the solar Eclipse and Dimensions of the lunar Shadow upon the Earth's Surface, considered as an *Ellipsoid*, and not a *Sphere*; in order to which, I pursued the most direct, concise, and genuine Method that Geometry could supply for that Purpose; and this very Method of Demonstration was, some years ago, invented by the GREATEST MATHEMATICIAN in EUROPE, the universally celebrated Mr. de MAUPERTUIS in his Treatise *sur la PARALLAX de la Lune*; and the same Principles and Method of Reasoning which he there employs for obtaining his *Dimensions Geographiques* (Sect. III.); *pour la Gravité* (Sect. IV.); *Recherche de la Difference des Parallaxes sur la Terre & sur le Globe* (Sect. VII.); *Lexodromiques* (Sect. XII); are the very same with those I have here used in these two Chapters; and no one that was not very dark indeed, could help seeing how ridiculous it must be to introduce the *Radius of Curvature* for such Purposes.

But what gives a Disrelish for these two Chapters, is, that they are, it seems, *of my own Growth*; this they say, but for what Reason I know not. I never regarded them as of my *own Growth*, being too conscious I was never able to *grow any Thing so good*. I thought every Body had known that this ingenious Method of Demonstration was the Invention of MAUPERTUIS, as much as that of *prime and ultimate Ratios* was of the great NEWTON.

I am therefore in no Humour to accept the Advice of these *Names* Gentry for rejecting that Method of Demonstration which I have received from the *greatest Names* in the Mathematical World. As to what they say of Mr. Simpson's Series being more simple, and better to calculate from than Mr. CLAIRAUT'S, I believe it will appear to be an errant Falshood to any one who shall compare them; for they will find that both the Series are the *same*, and Mr. Simpson positively declares they are *so*, in the Preface to his *Miscellaneous Tracts*.

From these Anecdotes, the Public will be very easily apprised how far they can confide in the Criticisms and Assertions of such Reviewers.